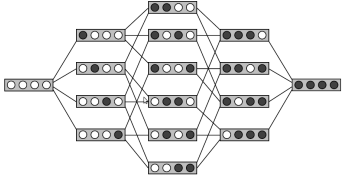
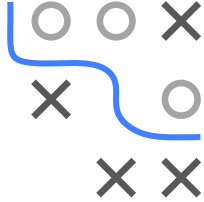
Supervised Learning

Wrapper methods



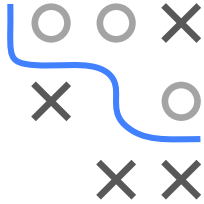


Learning goals

- Understand how wrapper methods work
- Understand how they coudl help in feature selection
- Know their advantages and disadvantages

INTRODUCTION

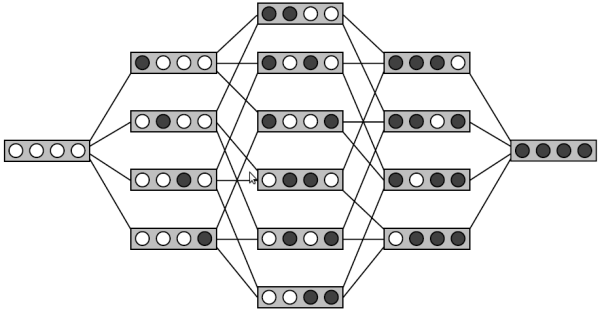
- Wrapper methods emerged from the idea that different sets of features can be optimal for different classification learners.
- Use the classifier itself to assess the quality of the feature sets.
- Evaluation on a test set or resampling techniques are used.
- A wrapper is nothing else than a discrete search strategy for S, where the test error of a learner as a function of S is now the objective criterion.

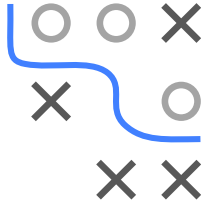


INTRODUCTION

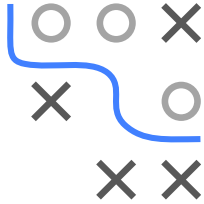
Wrappers have the following components:

- A set of starting values
- Operators to create new points out of the given ones
- A termination criterion





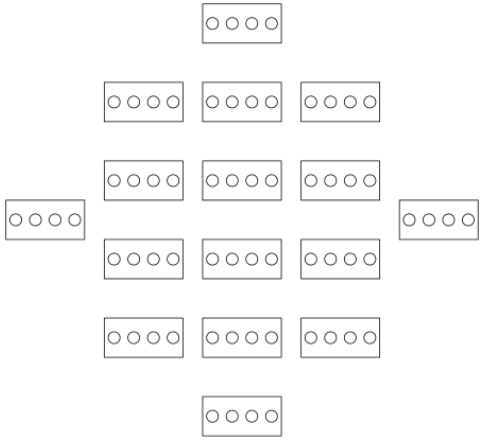
GREEDY FORWARD SEARCH

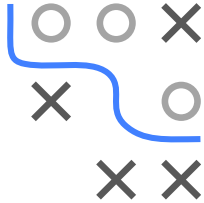


- Let $S \subset \{1, \ldots, p\}$, where $\{1, \ldots p\}$ is an index set of all features.
- Start with the empty feature set $S = \emptyset$.
- For a given set S, generate all $S_j = S \cup \{j\}$ with $j \notin S$.
- Evaluate the classifier on all S_j and use the best S_j.
- Iterate over this procedure.
- Terminate if:
  - the performance measure doesn't improve enough.
  - a maximum number of features is used.
  - a given performance value is reached.

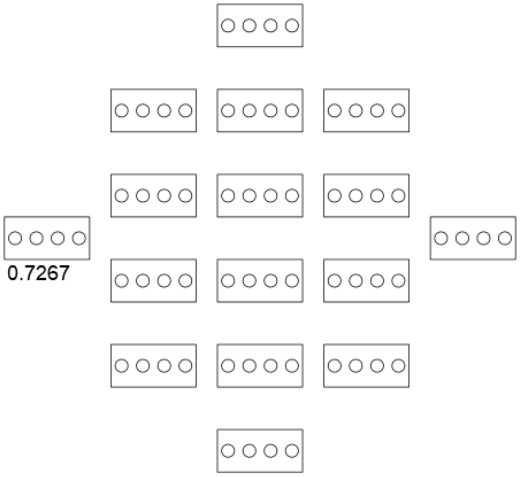
GREEDY FORWARD SEARCH

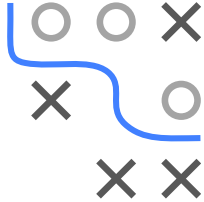
Example for greedy forward search on iris data:



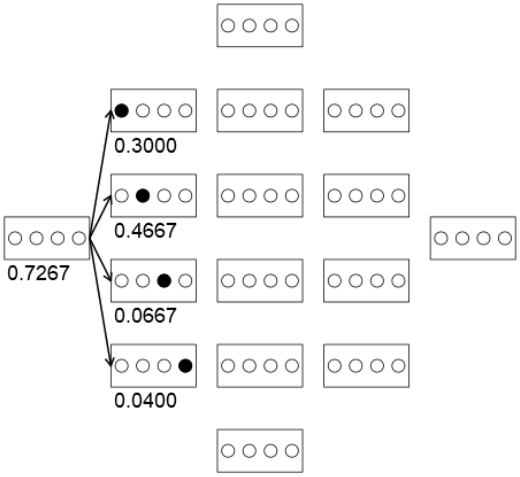


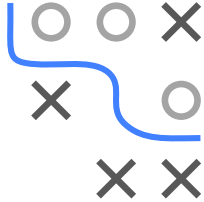
GREEDY FORWARD SEARCH



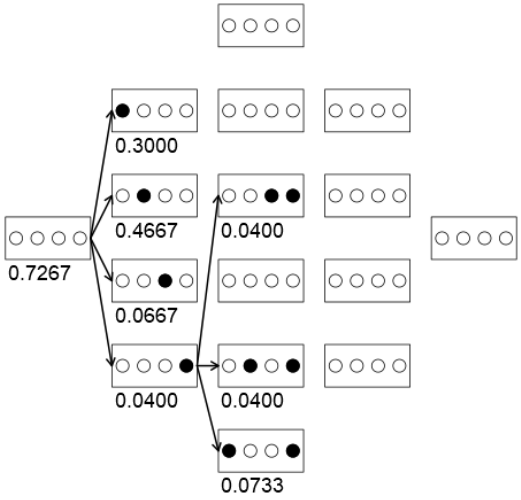


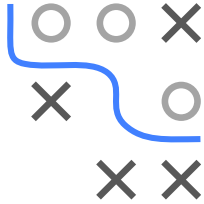
GREEDY FORWARD SEARCH



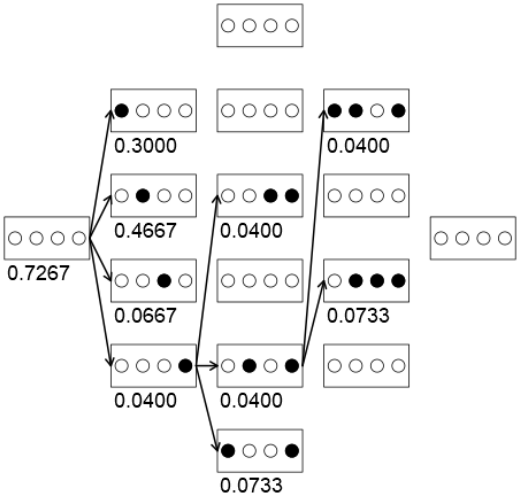


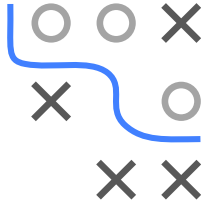
GREEDY FORWARD SEARCH



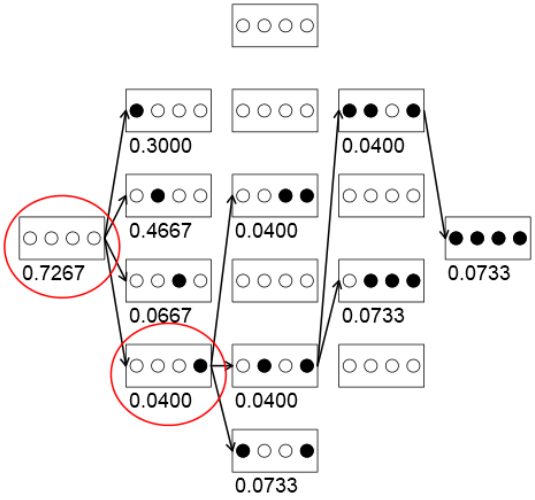


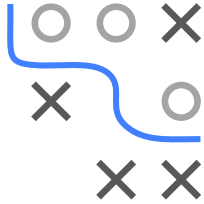
GREEDY FORWARD SEARCH



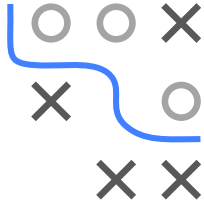


GREEDY FORWARD SEARCH





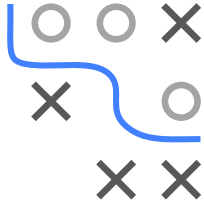
GREEDY BACKWARD SEARCH



- Start with the full index set of features $S = \{1, \ldots, p\}$.
- For a given set S generate all $S_j = S \setminus \{j\}$ with $j \in S$.
- Evaluate the classifier on all S_j and use the best S_j.
- Iterate over this procedure.
- Terminate if:
  - the performance drops drastically, or
  - a given performance value is undershot.

EXTENSIONS

- Eliminate or add several features at once to increase speed.
- Allow alternating forward and backward search.
- Randomly create candidate feature sets in each iteration.
- Continue search based on the set of features where an improvement is present.
- Use improvements of earlier iterations.

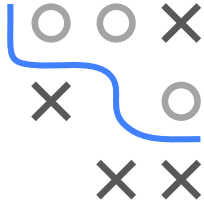


EXTENSIONS

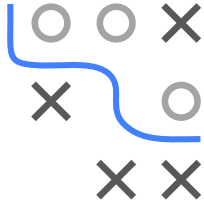
Algorithm A simple 1+1 genetic algorithm

1: Start with a random set of features S (bit vector b).
2: **repeat**
3: Flip a couple of bits in b with probability p.
4: Generate set S' and bit vector b'.
5: Measure the classifier's performance on S'.
6: If S' performs better than S, update $S \leftarrow S'$, otherwise $S \leftarrow S$.
7: **until** One of the following conditions is met:

- A given performance value is reached.
- Budget is exhausted.



WRAPPERS



Advantages:

- Can be combined with every learner.
- Can be combined with every performance measure.
- Optimizes the desired criterion directly.

Disadvantages:

- Evaluating the target function is expensive.
- Does not scale well if number of features becomes large.
- Does not use much structure or available information from our model.